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ABSTRACT

This continuum is designed to be used as a guide to aid science educators, elementary teachers, administrators, and others in developing elementary school science curricula. It is divided into five major competency areas: (1) processes of science; (2) biological science; (3) physical science; (4) earth and space science; and (5) attitudes (toward classwork, interests and careers, personal use of science, oneself, and science and society). Each competency area is divided into specific subgroups with each subgroup referenced to two or more competency indicators or expected student behaviors. Each indicator is designated by a letter in a grade level column (K-3 and 4-6) which suggests the level at which the competency may be introduced (I), where it should be developed for comprehension (D), and where it should be reinforced (R). Information on how to use this continuum is included. (JN)

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# A Recommended Science Competency Continuum for Grades K to 6 for Pennsylvania Schools

SE 045 549

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# A Recommended Science Competency Continuum for Grades K to 6 for Pennsylvania Schools

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## PREFACE

If the United States is to maintain or improve its world leadership position in the present technologically oriented era, we must dramatically improve the scientific and technical skills of our youth. This need, recognized by the Governor and the General Assembly, gave rise to the Pennsylvania Science and Mathematics Initiative. This publication is one part of that initiative.

This Continuum represents a distillation of outstanding national models for elementary science curricula combined with ideas which are uniquely Pennsylvanian. We wish to acknowledge the following groups and their publications for their contributions.

| | |
|---|---|
| Commonwealth of Virginia, Department of Education | *Standards of Learning Objectives* |
| Department of Defense Dependents Schools | *Science Goals and Objectives* |
| National Science Teachers Association | *A Recommended Model for Developing a K-12 Science Skills Continuum* |
| North Carolina, Department of Public Instruction | *Competency Goals and Performance Indicators K-12: Science* |

It is our hope that this K-6 science competency continuum will serve as a guide for those in the Commonwealth who wish to design and implement quality science curricula for our children.

Nancy Bires
Lynne Kepler
Donna Oliver
Bruce Smith
Ken Mechling, Director

## HOW TO USE THIS K-6 SCIENCE CONTINUUM

This Continuum is designed to be used as a guide to aid science educators, elementary teachers, administrators, and others in developing science curricula for the elementary school level. It is flexible enough to ensure K-6 science programs suited to the needs of all students, yet comprehensive enough to achieve well-balanced programs throughout the state.

The Continuum is divided into five major competency areas; Processes of Science, Biological Science, Physical Science, Earth and Space Science, and Attitudes, and each is further divided into specific subgroups. Each competency area subgroup is referenced to a group of competency indicators or expected student behaviors. Each indicator is but one example of a behavior which a student could display to demonstrate competency in a particular science area. For example, in the Processes of Science subgroup Observing, a student could exhibit competency by using one or more senses to observe objects, by correctly using hand lenses or microscopes, or by demonstrating other behaviors appropriate to Observing. It is especially important to note that statements in the competency indicators column are examples. Others may be used if they are more appropriate for the learners.

Each competency indicator is designated by a letter (I, D, or R) in the grade level column. (I) designates the level at which the competency may be introduced; (D) where it should be developed for comprehension; and (R) where it should be reinforced. A competency may be introduced at a higher level than indicated, if it has not been previously introduced, or it might be introduced at an earlier level if the class seems ready for it. Curriculum planners are encouraged to exercise their own judgment based upon the specific needs of children in their schools.

The Continuum can serve many different purposes. It may be used as a tool to evaluate science curricula being considered for adoption. For example, when reviewing science textbooks or programs, many teachers wonder if certain concepts or processes are appropriate of their grade level. This Continuum can help teachers make that decision.

Educators engaged in a long-range planning process may also wish to use the Continuum as a tool for assessing their present science curriculum. It can aid both in identifying what concepts, processes, and attitudes should be developed and assist in expressing expected student performance in behavioral terms.

Finally, the Continuum may be used as a reference for educators, parents, and other citizens interested in obtaining a better understanding of what Pennyslvania's K-6 students are expected to learn in science.

| COMPETENCY AREA | COMPETENCY INDICATORS | K-3 | 4-6 |
|---|---|---|---|
| | Each indicator is one of many behavioral examples which may be used to assess student competency. Others may be used to fit students' needs. | | |
| A. PROCESSES OF SCIENCE | The student will: | | |
| 1. Observing | a. observe objects or events in a variety of ways using one or more of the senses. | I,D,R | D,R |
| | b. identify properties of an object, i.e., shape, color, size, and texture. | I,D,R | D,R |
| | c. use indirect methods, i.e., hand lenses, microscopes, thermometers, to observe objects or events. | I,D,R | I,D,R |
| | d. observe objects or events by counting, comparing, estimating, and measuring. | I,D,R | D,R |
| 2. Classifying | a. identify properties useful for classifying objects. | I,D,R | I,D,R |
| | b. group objects by their properties or similarities and differences. | I,D,R | D,R |
| | c. construct and use classification systems. | I,D,R | I,D,R |
| 3. Inferring | a. suggest explanations for events based on observations. | I,D | R |
| | b. distinguish between an observation and an inference. | I,D | R |
| 4. Predicting | a. forecast a future event based on prior experience, i.e., observations, inferences, or experiments. | I,D | I,D,R |
| 5. Measuring | a. compare and order objects by length, area, weight, volume, etc. | I,D,R | D,R |
| | b. measure properties of objects or events by using standardized units of measure. | I,D | I,D,R |
| | c. measure volume, mass, weight, temperature, area, length, and time, using appropriate units and appropriate measuring instruments. | I,D | I,D,R |

| COMPETENCY AREA | COMPETENCY INDICATORS | K-3 | 4-6 |
|---|---|---|---|
| 6. Communicating | a. construct and use written reports, drawings, diagrams, graphs, or charts to transmit information learned from science experiences. | I,D,R | I,D,R |
| | b. verbally, ask questions about, discuss, explain, or report observations. | I,D,R | D,R |
| | c. after an investigation, report the question tested, the experimental design used, results, and conclusions drawn, using tables and graphs where appropriate. | I,D | I,D,R |
| 7. Using Space/Time Relations | a. describe an object's position, i.e., above, below, beside, etc., in relation to other objects. | I,D,R | D,R |
| | b. describe the motion, direction, spatial arrangement, symmetry, and shape of an object compared to another object. | I | I,D,R |
| 8. Defining Operationally | a. state definitions of objects or events in terms of what the object is doing or what is occurring in the event. | I,D | D,R |
| | b. state definitions of objects or events based on observable characteristics. | I,D | D,R |
| 9. Formulating Hypotheses | a. identify questions or statements which can and cannot be tested. | I | D,R |
| | b. design statements, i.e., questions, inferences, predictions, which can be tested by an experiment. | I,D | D,R |
| 10. Experimenting | a. design an investigation to test a hypothesis. | I,D | D,R |
| | b. conduct simple experiments. | I,D,R | I,D,R |
| | c. recognize limitations of methods and tools used in experiments, i.e., experimental error. | I | I,D,R |
| | d. utilize safe procedures while conducting investigations. | I,D,R | I,D,R |

| COMPETENCY AREA | COMPETENCY INDICATORS | K-3 | 4-6 |
|---|---|---|---|
| 11. Recognizing Variables | a. identify the manipulated (independent) variable, responding (dependent) variable, and variables held constant in an experiment. | I | I,D,R |
| | b. control the variables in an investigation. | I | I,D,R |
| 12. Interpreting Data | a. organize and state in his/her own words information derived from a science investigation. | I,D | D,R |
| | b. revise interpretations of data based on new information or revised data. | I | D,R |
| 13. Formulating Models | a. create a mental, physical, or verbal representation of an idea, object, or event. | I,D | I,D,R |
| | b. use models to describe and explain interrelationships of ideas, objects, or events. | I,D | I,D,R |
| B. BIOLOGICAL SCIENCE | Each indicator is one of many behavioral examples which may be used to assess student competency. Others may be used to fit students' needs. | | |
| | The student will: | | |
| 1. Characteristics of Living Things | a. describe characteristics of living and non-living things. | I,D,R | I,D,R |
| | b. classify familiar objects as living or non-living. | I,D | R |
| | c. state basic needs of living things. | I,D | R |
| | d. identify the cell as the basic unit of structure of living things. | I | I,D,R |
| | e. illustrate the life cycle of a living thing, i.e., bean plant, insect, human. | I,D | I,D,R |
| | f. identify similarities and differences in physical characteristics of living things and use them to construct a classification system. | I,D,R | I,D,R |

| COMPETENCY AREA | COMPETENCY INDICATORS | K-3 | 4-6 |
|---|---|---|---|
| 2. Microorganisms | a. observe, identify, and experiment with common organisms found in pond water. | I,D, | I,D,R |
| | b. construct a food chain and identify the role of microorganisms such as bacteria, algae, and protozoans. | I | I,D,R |
| | c. explain the role of microorganisms in causing and transmitting disease. | I | I,D,R |
| 3. Plants | a. identify the basic characteristics of plants. | I,D | R |
| | b. explain the process and importance of photosynthesis. | | I,D |
| | c. illustrate ways seeds can be dispersed. | I | I,D |
| | d. design and conduct an investigation to determine the effect of a selected variable, i.e., light, water, fertilizer, on plant growth. | I,D | I,D,R |
| | e. identify ways people use plants. | I,D | I,D,R |
| 4. Animals | a. compare similarities and differences of various groups of animals. | I,D,R | I,D,R |
| | b. cite examples of how animals have adapted to their environment. | I,D | I,D,R |
| | c. observe and describe animal behavior. | I,D | I,D,R |
| | d. report orally or in writing the results of an investigation concerning animal behavior in response to stimuli. | I,D | I,D,R |
| | e. identify humans as mammals when given a list of mammalian characteristics. | I | D,R |
| 5. Human Biology | a. identify the major body systems, i.e., digestive, circulatory, respiratory, their component parts and their functions. | I | I,D,R |
| | b. indicate the consequences of the use of alcohol, narcotics, and tobacco. | I,D | I,D,R |
| | c. demonstrate effective personal health decisions by exhibiting good hygiene and nutritional practices. | I,D,R | I,D,R |
| | d. design and conduct investigations of their own body functions, i.e., heartbeats, sensory perception, lung volume, reaction time. | I,D | I,D,R |

| COMPETENCY AREA | COMPETENCY INDICATORS | K-3 | 4-6 |
|---|---|---|---|
| 6. Ecology | a. identify local plant and animal species and describe their natural histories. | I,D | I,D,R |
| | b. construct food chains and food webs to illustrate energy flow in an ecosystem. | I | I,D,R |
| | c. describe ways in which populations of plants and animals in a community interact with one another and their environment. | I | I,D,R |
| | d. explain the impact of one's personal life on the environment and identify and practice methods for lessening that impact. | I | I,D,R |
| | e. debate the positive and negative effects of environmental policies and practices in the local community. | | I,D |
| | f. construct and maintain an aquarium or terrarium habitat for plants and animals. | I,D | D,R |
| 7. Heredity and Evolution | a. match offspring with their parents. | I,D,R | R |
| | b. discuss similarities and differences between individuals within their own families. | I | I,D |
| | c. identify human traits which are inherited, i.e., eye color, hair color, ear lobe attachment. | | I |
| | d. describe how plants and animals have both structural and behavioral adaptations which help them to survive. | I | I,D |
| | e. apply concepts related to heredity, adaptation, and natural selection to explain evolution. | | I |
| C. PHYSICAL SCIENCE | Each indicator is one of many behavioral examples which may be used to assess student competency. Others may be used to fit students' needs. | | |
| | The student will: | | |
| 1. Matter | | | |
| A. Form/State | a. demonstrate that all matter takes up space and has weight. | I,D | D,R |
| | b. differentiate among solids, liquids, and gases and give examples of each. | I,D | D,R |

| COMPETENCY AREA | | COMPETENCY INDICATORS | K-3 | 4-6 |
|---|---|---|---|---|
| | A. Form/State (continued) | c. describe changes of state; solid, liquid, and gas, i.e., ice cube melting and evaporating. | I,D | I,D,R |
| | | d. define density as mass per unit volume. | | I |
| | | e. explain that energy interacts with matter to produce change. | | I,D |
| | | f. distinguish between chemical and physical changes. | I,D | I,D,R |
| | B. Water | a. describe water as a unique substance essential to living functions and to many natural inorganic changes. | I | D |
| | | b. predict ability of objects to float in water. | I,D | D,R |
| | | c. use the pH scale to test for the acidity or alkalinity of a water solution. | | I,D |
| | C. Elements | a. identify substances as elements, compounds, or mixtures. | I | D |
| | | b. describe properties of some common elements. | I | D |
| | | c. differentiate between metals and non-metals. | I | D |
| | D. Atoms and Molecules (Basic Units) | a. draw a diagram or make a model of an atom. | | I |
| | | b. distinguish between an atom and a molecule. | | I |
| 2. | Energy | | | |
| | A. Basic Characteristics of Energy | a. define energy as the ability to do work. | | I |
| | | b. measure energy in appropriate units. | | I,D |
| | | c. differentiate between kinetic and potential energy and demonstrate an example of each. | | I,D |
| | | d. identify forms of energy involved in energy transformations, i.e., chemical, light, heat. | | I,D |
| | | e. describe and practice some methods of conserving energy. | I,D | I,D,R |

| COMPETENCY AREA | COMPETENCY INDICATORS | K-3 | 4-6 |
|---|---|---|---|
| B. Electricity | a. perform simple demonstrations of static electricity using commonly available materials, i.e., plastic, glass, paper, rubber. | I | D |
| | b. construct electrical circuits and predict performance of variables using batteries, bulbs, and wires. | I,D | I,D,R |
| | c. test and classify materials as conductors or non-conductors of electricity. | I | I,D,R |
| | d. measure electrical consumption using common units. | | I,D |
| C. Magnetism | a. describe and demonstrate some properties of magnetism. | I,D | D,R |
| | b. sort a collection of objects according to magnetic and non-magnetic properties. | I,D | D,R |
| | c. predict attraction and repulsion between magnetic poles. | I | D,R |
| | d. construct an electromagnet. | | I,D |
| D. Light/Color | a. demonstrate light as generated by electrical or chemical energy conversion. | I | D |
| | b. predict, demonstrate and describe the effects of lenses, mirrors, and prisms on the path of light. | I | D |
| | c. generate and identify different colors. | I,D,R | I,D,R |
| | d. create and describe an optical spectrum. | | I |
| E. Sound | a. describe variation in sound, i.e., low, high, quiet, loud, pleasant, harsh. | I,D,R | D,R |
| | b. identify sound as produced by vibration of objects. | I | D |
| | c. recognize variations in pitch and frequency. | I | I,D |
| | d. construct several sound transmitting devices, i.e., paper cup telephones, electrical buzzer, rubber band instruments. | I | I,D |

| COMPETENCY AREA | COMPETENCY INDICATORS | K-3 | 4-6 |
|---|---|---|---|
| F. Heat | a. demonstrate heat as a change agent, i.e., cooking, melting, reforming. | I | D |
| | b. measure temperature in appropriate units. | I | D |
| | c. explain temperature as molecular motion. | | I |
| | d. differentiate between heat and temperature. | | I |
| | e. illustrate the heat transfer mechansims; conduction, convection, radiation. | I | D |
| | f. demonstrate heat generation and loss in energy exchanges. | | I |
| G. Force and Machines | a. identify any pushing or pulling on an object as a force. | I,D | D,R |
| | b. give examples of force that move objects. | I,D | D,R |
| | c. identify gravity as a force. | I | D |
| | d. measure forces with balances, springs, and other appropriate devices. | I | D |
| | e. define inertia as the resistance to change from an outside force. | | I |
| | f. identify, construct, and use simple machines. | I,D | I,D,R |
| | g. use simple machines to predict the effects of force, changes of direction, and friction. | | I,D |
| | h. demonstrate and describe how simple machines are used in everyday life. | I | I,D,R |
| D. EARTH AND SPACE SCIENCE | Each indicator is one of many behavioral examples which may be used to assess student competency. Others may be used to fit students' needs. | | |
| | The student will: | | |
| 1. Geology | a. identify major geological features of the earth's surface. | I | I,D |
| | b. test rocks for color, hardness, crystalline structure, magnetism, and so on. | I | I,D |
| | c. classify rocks by their method of formation; igneous, sedimentary, and metamorphic. | | I |
| | d. distinguish between rocks and minerals. | | I |

| COMPETENCY AREA | COMPETENCY INDICATORS | K-3 | 4-6 |
|---|---|---|---|
| 2. Earth Changes | a. state in his/her own words, how the earth has changed through time. | | I |
| | b. identify forces tending to change the earth's surface, i.e., water and air flow, vulcanism, humans. | I | I,D |
| | c. explain and illustrate how mountains, valleys, and oceans are formed. | | I |
| | d. describe the process of plate tectonics and its meaning in terms of continent location. | | I |
| 3. Ancient Life | a. compare ancient life with life today. | I | D |
| | b. cite examples of fossils that are remnants of prehistoric plants or animals. | I | D |
| | c. make a simulate fossil. | I | D |
| 4. Natural Resources | a. list different natural resources, i.e., fossil fuels, uranium, salt, water, air, metal ores, and soil. | I | I,D |
| | b. discriminate between renewable and non-renewable resources and describe ways people sometimes misuse or waste them. | | I,D |
| 5. Weather and Climate | a. observe, describe and record daily weather conditions over a short period of time. | I,D | I,D,R |
| | b. interpret a weather map. | | I,D |
| | c. apply the concept of the water cycle to daily weather conditions. | | I,D |
| | d. identify cloud types and relate them to weather. | I | I,D |
| | e. construct simple weather instruments and use them to measure weather phenomena, i.e., pressure, wind direction, and precipitation. | I | I,D |
| | f. describe seasonal variations and relate them to the tilt of the earth's polar axis. | | I |
| | g. explain how factors such as temperature, water, topography, and wind affect climate. | | I,D |
| | h. describe climatic zones of the earth, i.e., polar, temperate, tropic. | I | I,D |

| COMPETENCY AREA | COMPETENCY INDICATORS | K-3 | 4-6 |
|---|---|---|---|
| 6. Solar System | a. identify the sun as the source of the earth's energy. | I | D |
| | b. use models to describe the interrelating movements of the earth, sun, and moon and their effects on the earth, i.e., time measurements, eclipses, and phases of the moon. | I | I,D |
| | c. explain tides as earth-moon-sun gravitational attraction. | | I |
| | d. compare and contrast the characteristics of the planets in our solar system. | I | I,D |
| | e. describe some of the scientific and technological discoveries resulting from space programs. | | I,D |
| 7. Universe | a. identify major structures found in the universe, i.e., stars, constellations, and galaxies. | I | I,D |
| | b. state one or more theories for the origin of the universe. | | I |
| E. ATTITUDES | Each indicator is one of many behavioral examples which may be used to assess student competency. Others may be used to fit students' needs. | | |
| | The student will: | | |
| 1. Toward Classwork | a. cooperatively share responsibilities and tasks. | I,D | I,D,R |
| | b. use science materials in a safe, responsible manner. | I,D,R | I,D,R |
| | c. demonstrate proper care and handling of living organisms and show respect for life. | I,D,R | I,D,R |
| | d. demonstrate enthusiasm toward science learning experiences. | I,D,R | I,D,R |
| | e. stay with task in search of a solution. | I,D,R | I,D,R |
| 2. Toward Interests and Careers | a. pursue science-related leisure time activities. | I,D | I,D,R |
| | b. voluntarily seek additional information about science. | I,D | I,D,R |
| | c. seek information about careers in science and technology. | I | I,D,R |

| COMPETENCY AREA | COMPETENCY INDICATORS | K-3 | 4-6 |
|---|---|---|---|
| 3. Toward Personal Use of Science | a. use an objective approach in problem-solving. | I,D | I,D,R |
| | b. display a willingness to consider other points of view. | I,D,R | I,D,R |
| | c. demonstrate divergent thinking when solving problems. | I,D | I,D,R |
| | d. demonstrate curiosity about science-related phenomena. | I,D,R | I,D,R |
| | e. apply science and technology to common life tasks. | I | I,D,R |
| 4. Toward Oneself | a. display confidence in his/her own ability to use science successfully. | I,D,R | I,D,R |
| | b. demonstrate a positive self-concept through the study of science. | I,D,R | I,D,R |
| 5. Toward Science and Society | a. select cause-and-effect relationships to explain contemporary problems. | I | I,D |
| | b. identify science as a way of solving current problems. | I,D | I,D,R |
| | c. describe scientists as persons sensitive to normal human concerns. | I | I,D,R |
| | d. demonstrate an awareness of the need for conservation, preservation, and wise use of natural resources. | I,D | I,D,R |
| | e. explain how science and technology can have both positive and negative effects on one's personal life. | I | I,D |